

**Electromagnetic ring expansion as a tool to study dynamic  
deformation and fracture in metals**

William H. Gourdin

University of California  
Lawrence Livermore National Laboratory  
P.O. Box 808  
Livermore, CA 94551

*Abstract*

I will show how studies of electromagnetically driven rings can be used to provide information and insight regarding the mechanical behavior of metals at strain rates of up to  $10,000 \text{ s}^{-1}$  and temperatures as high as  $400^\circ\text{C}$ . I will describe a relatively simple experimental apparatus, and analyze the relevant electrodynamics in detail. I will then show that the predictions of this analysis are generally in excellent quantitative agreement with observations of ring expansion speeds obtained with laser interferometer (VISAR) measurements. The accuracy with which the electrodynamics can be predicted makes it possible to extract the constitutive (stress-strain) behavior of the ring material by judiciously selecting switching times so that electromagnetic forces are small and the ring is essentially in free expansion. I will present examples of measurements of the constitutive behavior of copper obtained with this technique, and demonstrate that they are consistent with data obtained with conventional test equipment at much lower rates. I will also briefly describe a modification of the method which can be used to launch metals with conductivities lower than that of copper. The failure of the ring can be monitored with high-speed photography and the fragments easily contained for later recovery. I will conclude, therefore, with a brief discussion of the observed trends in dynamic ductility and fragmentation as a function of strain-rate and material grain size.

\*Work was performed under the auspices of the US Department of Energy at Lawrence Livermore National Laboratory under contract W-7405-Eng-48.